POST-SHOCK COOLING AND ANNEALING WITHIN L-GROUP ORDINARY CHONDRITES. Marvin E. Bennett and Harry Y. McSween Jr., Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410.

Two cation-exchange thermometers were applied to electron microprobe data from a petrologically diverse suite of L-group ordinary chondrites in an attempt to determine the effects of post-shock cooling and annealing on mineral re-equilibration. All analyses were taken from matrix minerals, which should be more sensitive to secondary thermal effects then those within chondrules. Fe - Mg exchange between olivine and spinel [1] was utilized to monitor cooling rates of high-temperature mineral phases. Ni exchange between metal and troilite [2] provided information on post-shock annealing within the low-temperature mineral portion. Both thermometers have been calibrated at temperatures and pressures appropriate for meteorite study.

Samples selected for this study reflect the diverse thermal and shock history recorded in L-group ordinary chondrites. Hallingeberg, Bjürbole, and Ausson are low-shock (below S4 shock stage, [3]) chondrites that lack evidence of post-shock melting. Kyushu and McKinney are high-shock chondrites (above S4 stage) that contain small melt pockets of metal, sulfides, and silicates. In addition, McKinney has a shock-blackened texture produced by rapid injection of metal and sulfide into surrounding fractures [3]. Y793421, Y75097, and EET87555 are L chondrite breccias that contain small, isolated melt inclusions. Shaw contains numerous small silicate melt dikes that have been injected into surrounding brecciated materials (the previously described 'gray lithology' [4]). PAT91501 has a cumulus texture and a mineralogy reflecting a possible history of partial to complete melting [5].

Fig. 1 is a summary of the temperatures obtained by both geothermometers. The lengths of the bars indicate the ranges of temperature recorded for six to ten mineral pairs from each sample. Both analytical and calibration errors for the two thermometers are approximately 50°C.

Low-shock samples yield olivine-spinel temperatures appropriate for slowly cooled, unequilibrated L chondrites (650-700°C). The range of metal-sulfide temperatures correlate with the rate of post-shock annealing and not with petrologic type. Hallingeberg (L3, S3) shows the greatest variation in metal-sulfide temperatures while Bjürbole (L-LL4, S1) displays the smallest variation in temperature range. Faster cooling from an initially higher degree of post-shock reheating (for Hallingeberg), with slower cooling from an initially lower degree of reheating (for Bjürbole), could explain this apparent trend. Ausson (L5, S2) has a temperature range that is intermediate between the above samples. The two Yamato breccias also plot in the same region as the unequilibrated chondrites. Since these breccias contain melted L chondrite inclusions the low temperatures recorded by both thermometers could indicate very slow rates of cooling from samples that originated beneath a thick, thermally insulating blanket of regolith.

High-shock samples record olivine-spinel temperatures within the range of equilibrated L chondrites (~750°C, from [6]). Kyushu displays a wider range of metal-sulfide temperatures than seen in the unequilibrated chondrites owing to the proximity of large shock-induced melt pockets to several analyzed mineral pairs. McKinney displays a much narrower range in sulfide-metal temperatures due to the rapid heating (with subsequent rapid cooling) of metal and sulfide prior to portions being injected into pre-existing fractures. The breccia EET87555 has a mean for both thermometers that falls within the same temperature range as the high-shock samples. The extreme range of temperatures seen in this sample, however, suggests that the fragments that comprise this breccia formed from thermally diverse sources and that, once accreted, the sample was not buried to any great depth within the parent body.

PAT91501 is a sample chondrite melt. The high temperatures recorded by the olivine-spinel thermometer are consistent with other evidence suggesting an origin in a melt sheet within an impact crater on the parent body [6]. Metal-sulfide temperatures are similar to those in unequilibrated L chondrites. Such temperatures could have been produced if this melt sheet were covered by regolith material, resulting in slower cooling of these phases. Slow cooling is also consistent with the coarse grained, cumulate texture of this sample.

Olivine-spinel temperatures recorded in the gray lithology of Shaw are intermediate between the unmelted equilibrated samples and the PAT melt inclusion. Either the dike material was not wholly

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melted before it was shock-injected into the surrounding breccia or the breccia acted as an insulator to allow these minerals to equilibrate to lower temperatures. Metals and sulfides are absent from this portion of Shaw. The temperatures that this mineral pair preserves are directly correlated to distance from this lithology. Pairs adjacent to the melt dike record higher temperatures (near 750°C). Those within a centimeter of the dike record lower temperatures (~550°C).

References: [1] Sack R.O. and Ghiorso M.S. (1991) *Am. Mineral.* **76**, 827-847. [2] Bezmen N.I. et al. (1978) *Geochem. Intern.* **15**, 120-127. [3] Stöffler D. et al. (1991) *Geochim. Cosmochim. Acta* **55**, 3845-3867. [4] Taylor G.J. et al. (1979) *Geochim. Cosmochim. Acta* **43**, 323-337. [5] Harvey R.P. (1993) Submitted to *Meteoritics*. [6] McSween H.Y., Jr. et al. (1988) in *Meteorites and the Early Solar System*, 102-113.

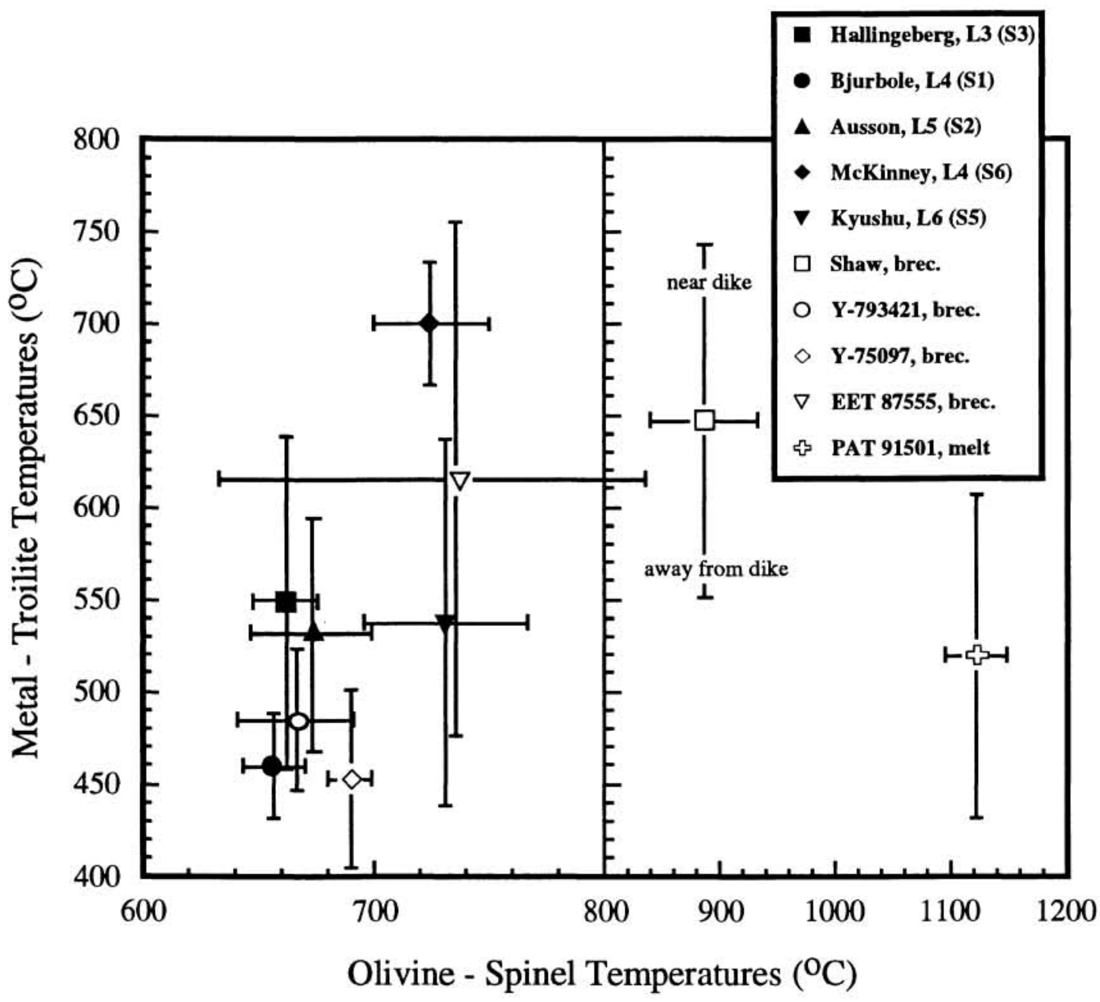

Figure 1. Means and temperature ranges for two thermometers plotted for unmelted chondrites (solid symbols) and breccias and melt inclusions (open symbols). Errors for each thermometer would extend each bar 40 to 50°C.